PATENT SPECIFICATION

DRAWINGS ATTACHED

997,721

997,721

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COMPLETE SPECIFICATION

Improvements in or relating to a Process for Fixing a Tube in a Bore

We, COMMISSARIAT A L'ENERGIE ATOMIQUE, an Organisation created in France by Ordonnance No. 45—2563 of 18th October, 1945, of 69 rue de Varenne, Paris 7, France, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to a process for fixing a tube in a bore.

In fact, it is often necessary to fix a tube in at least one end of a bore, and this fixing must have tensile strength, be fluid-tight under the pressure of fluids inside and outside the tube, and enable objects to circulate freely in the internal space bounded by the tube and the bore in which it is fixed.

Some solutions have already been found to problems of this kind, and among the best known may be cited the following embodiments:

a) All the conventional systems using straps and pipe-unions. Unfortunately, these systems are bulky, and necessitate the use of packings which, in order to give a fluid-tight seal, must in practice be made of organic materials which do not always satisfactorily withstand corrosive fluids or nuclear radiation.

Furthermore, such systems do not enable the tube to be placed in position via the interior of the bore in which it is desired to fix it, nor do they allow both ends of the tube to be satisfactorily fixed in the bores of two relatively fixed pieces.

b) When the tube is sufficiently thin, it is possible to adopt methods characteristic of smithing work with metals in sheet form, that is to say to drive or crimp it on to the previously profiled sleeve. This solution is suitable only for small thicknesses, and does not in general provide a degree of fluid-tightness greater than that required by current industrial practice.

c) Swaging or tube-expanding processes, which consist in expanding the end of the tube over a length of the order of the diameter by means of ovals or rollers moving in circular or helical fashion.

These processes only give a fluid-tight joint when the material of which the tube is made is not harder than the piece to which it is fixed, and even when this condition is fulfilled the degree of fluid-tightness is far far complying with the requirements of certain fields. The deformations involved are considerable; the tube is elongated, which upsets the fixing to two fixed pieces, and in general impairs the pieces to which it is desired to make a joint.

d) An improvement in the foregoing processes consists in carrying out expansion only over short lengths (of the order of a few times the thickness of the tube) and making the joint by a plurality of expansions (two or three) spaced at a distance greater than the width of expansion. This eliminates the disadvantages bound up with the large deformations in the foregoing system, but the tensile strength of such a joint is always somewhat mediocre, and the provision of a fluid-tight seal is attended with the same dis-

advantages, namely that a degree of fluid-tightness which is sufficient in current industrial practice, but insufficient in the face of standards as stringent as those encountered in nuclear industries, can only be obtained with a value of expansion within a very narrow band, and only then if the material of which the tube is made is less hard than that of which the plate is made.

Furthermore, this degree of fluid-tightness—like that in the foregoing solution—does not withstand temperature variations of several tens of degrees when the materials of which the tube and the bored piece are made do not have the same coefficient of thermal expansion.

The present invention provides a process by which the disadvantages of the foregoing solutions may be overcome.

According to the present invention there is provided a process of fixing a tube in fluid tight manner within a bore having in its inner surface a plurality of annular grooves of rectangular cross-section, by means of an expansion device comprising a plurality of cylindrical rollers, wherein the tube is positioned in the bore, and the device is positioned in the tube, with the said rollers opposite one of said grooves, and said rollers are then pressed radially outwardly against the wall of the tube and rotated about the axis thereof while being held against axial movement relative to the tube, so that the said tube is expanded locally into said groove by the purely radial force exerted by the rollers.

By the expression "purely radial force" must be understood that there is no longitudinal component parallel to the axis of the tube in the forces involved in producing expansion. To this end, the expander tool is first of all brought into position facing a groove, and only then is the radial expanding force applied; this prevents any heavy stresses from being developed in the tube, such stresses being set up when the expander tool moves in the tube in continuous translation, for example with a helical movement, as is the case in previously known expansion processes.

In a variant of use of the process according to the invention, the tube comprises on its internal face cylindrical projections extended by suitable linking portions of smaller internal diameter than the tube, and intended to be placed in position, before expansion, facing corresponding grooves in the bore.

This variant in the use of the process makes it possible to prevent the local expansions which are produced from resulting in a groove in the internal surface of the tube facing the expansion channels, which groove would have the disadvantage of to some extent reducing the tensile strength of the tube. Although in the majority of cases of industrial use of joints produced in accordance with the invention (placing the interior of the tube under pressure) the axial stress in the tube remains appreciably less than the circumferential stress, there are certain particular cases in which the main mechanical force is a tractive force and not one of pressure. In all cases of this kind in which the tension (force per unit length) is greater axialy than circumferentially, the joint produced leads to a reduction in the possible tensile strength of the tube.

The appliance used for carrying out the process in accordance with the invention in order to expand the tube may be of known type essentially comprising an annular cage housing a certain number of rollers which are free in the cage and are set in rotation by an internal conical piece linked to a driving shaft.

It is particularly advantageous for the length of the rollers used in order to impart expansion to the tube to be appreciably greater than the width of the corresponding groove in the sleeve to which it is desired to fix the tube. Preferably, the width of the groove is between one third and two thirds of the length of the rollers and hence of the expansion produced.

It is also desirable for the depth of the groove to be such that the tube, once expansion has been carried out, cannot come into contact with the base of the groove. In addition, the value of expansion is not independent of the thickness of the tube to be fixed, and the best results are obtained when this expansion is between 15 and 30% of the thickness of the tube. Finally, the diameter of the rollers used for expansion purposes must be at least equal to four times the thickness of the tube, and it is advantageous, if correct use is made of the process, to use a low rotational speed and a small axial inward driving force for the cone of the expander appliance.

Among the most important advantages which the invention confers, there may be cited;

—the small bulk of the joint which is made;

—the possibility of fitting the tube via the interior of the pieces to which it is being fixed, since the process allows sufficient clearance for this purpose;

—the ease of making a joint according to the invention at a distance;

—the degree of fluid-tightness which is obtained as soon as the expansion reaches a critical value of the order of 15% of the thickness, and which is maintained for all greater degrees of expansion (which makes embodiment very easy because there is no tolerance on driving in);

—the possibility of obtaining a fluid-tight seal just as easily when the material of

which the tube is made is appreciably harder than that of which the sleeve is made, and even more so when the materials are equally hard;

—the small forces involved, and the virtually negligible deformation of the pieces to which the tube is being fixed;

—the tensile strength of the joint which is obtained, this being greater than a tractive force corresponding to a stress on the tube above the elasticity limit of the material of which it is made (in the usual cases greater than 2/3 of the breaking stress);

—the fluid-tight seal withstands large temperature variations if the materials have the same coefficient of expansion, and still greater changes in temperature when the materials do not have the same coefficient of expansion. The order of magnitude of these changes may be determined in the following manner: they correspond to the occurrence between two expansions of a longitudinal force due to differential thermal expansions of the order of 1/5 of the tensile strength of the joint, which allows for variations of about a hundred degrees Centigrade with conventional materials.

The invention may be advantageously applied to cases in which conventional or welded pipe-unions cannot be used. When the material of which the tube is made has the same coefficient of expansion as that constituting the bore to which it is to be fixed, connections capable of withstanding high temperatures may be made, and the present invention may be applied to fixing boiler and heat exchanger tubes.

A particularly interesting application to the case in which the materials do not have the same coefficient of expansion, but are nevertheless subjected only to a small range of temperature variation, relates to joining pressure tubes to their extensions in liquid-moderated nuclear reactors using a gas as a heat-carrying fluid.

Two non-limitative examples of use of the process for fixing a tube in fluid-tight fashion in a bore to which the invention relates will be described hereinafter with reference to the appended diagrammatic Figures 1 to 6.

Figure 1 is a diagrammatic view, sectioned along the axis, of a tube of constant thickness before fixing in a bore by the process according to the invention.

Figure 2 illustrates in axial section the respective positions of the bore, the tube, and an expander roller before expansion, in the case of a tube provided with internal projections.

Figure 3 illustrates the appearance of the same tube after expansion in axial section.

Figure 4 illustrates an expansion device of known type which is employed on carrying out the process of which the invention relates.

Figure 5 is a sectional view along AA of the appliance in Figure 4.

Figure 6 is a sectional view along BB of this same Figure 4.

Figure 1 illustrates the tube 1 which it is desired to fix, in fluid-tight fashion and with tensile strength, to the bored sleeve 2.

The sleeve 2 comprises annular grooves such as 3 and 4, intended to receive the subsequent expansions of the tube 1 which are produced by a purely radial force under the action of the tool in Figure 4, in line with each groove successively; in the particular example of embodiment to which reference is made here, the tube 1 has an internal diameter of 91.1 mm. and an external diameter of 99.3 mm.; it is made of steel.

The sleeve 2 is made of steel of the same quality, and its internal diameter is 100.02 mm.; in this way, the clearance between the tube 1 and the sleeve 2 is of the order of 6/100 to 1/10 of a millimetre at the radius; the rectangular grooves 3 and 4 are 5 mm. wide, 1.05 mm. deep, and at a distance of 25 mm. from one another.

Figure 2 illustrates, on a larger scale, the sleeve 2 positioned opposite one of the grooves 3 which are intended to receive the subsequent expansions of the tube 1 caused by the action of the expansion device whereof one of the rollers is diagrammatically illustrated at 8.

In this embodiment, the tube 1 comprises an annular projection 16, opposite the groove 3, and linked to the rest of the tube 1 by linking portions 17. The length of the projection 16 must be greater than that of the corresponding groove 3, and practically of the order of magnitude of the length of the expander rollers.

Figure 3 shows the appearance of the tube 1 after expansion, the projection 16 having virtually disappeared in favour of a smooth cylindrical internal wall 17.

The essential advantages conferred by this variant of use are chiefly concerned with the resistance of the tube to axial forces, which remains the same over the whole length of the tube because no groove remains after expansion. In addition, this imparts to the tube, after the joint has been made, an internal surface which is practically smooth and can therefore easily be used for sliding objects into the tube, or for attaining lower sensitivity to corrosion.

Tubes comprising internal projections may be produced by any suitable means known to the Technician, more particularly starting from tubes with extra end thickness.

Figures 4, 5 and 6 illustrate an expander appliance of known type which may be used; this essentially comprises a certain number of rollers, such as 8, mounted between a body 5 and a cheek 6 bounding a cage 7. The number of rollers, which is five in the

example of embodiment in Figure 2, is not absolutely critical; however, it must be greater than three. The length of each of these rollers in the example described in non-limitative fashion is 10 mm., and their diameter is 26 mm. journalled inside the body 5 there is a cone 9 for driving the rollers 8, which cone has a taper of 2%, and base diameters of 40 and 41.5 mm. respectively. The base 10 of the cone is mounted on a mandrel 11 which is rotated by a driving shaft not illustrated.

A nut 12, by being screwed on to the body 5, brings the spacer 13 to bear against the ball thrust race 14.

In order to fix the tube 1 to the sleeve 2 under these conditions, the appliance is kept in abutment against the said sleeve 2 with the aid of a spacer such as 15, so that the median plane of the rollers 8 coincides with the median plane of the groove 3. The cone 9 is set in rotation by way of the mandrel 11, upon which a constant inward driving force is simultaneously exerted. This force drives the cone 9 into the body 5 (which is held against axial movement by the spacers 13 and 15) and jams the cone against the rollers 8, which are forced radially outwardly against the tube. The cone is thus effectively locked solid with the body 5, which therefore rotates with the cone, and the rollers are rotated about the axis of the tube and effect local expansion thereof into the groove 3. In the particular example being described, the speed of rotation is 60 revolutions per minute, and the inward driving force is 30 kilograms. Under these conditions, the operation is stopped when the cone has been driven in for 120 mm., which gives an expansion of the order of one millimetre at the radius. The same operation may clearly be subsequently repeated on a level with another groove.

The joint thus obtained between a steel tube and a sleeve of this same metal was subjected to an internal pressure of 60 hectopiezes of nitrogen, and exhibits a degree of fluid-tightness characterised by an internal leak of less than 0.1 milligram of gas per day; this degree of fluid-tightness is maintained whatever the temperature variations between ambient temperature and 300°C. The tensile strength of the joint was found to be greater than thirty tons.

In another example of use of the joining process to which the invention relates, the tube 1 is made of zircalloy 2, and the sleeve 2 of 18/8 stainless steel in the cold-hardened state due to machining. The resulting fluid-tightness is of the same quality as in the foregoing case, and is maintained within a field of temperature between ambient temperature and 100°C. The tensile strength of the joint is greater than forty tons.

WHAT WE CLAIM IS:—

1. A process of fixing a tube in flight tight manner within a bore having in its inner surface a plurality of annular grooves of rectangular cross-section, by means of an expansion device comprising a plurality of cylindrical rollers, wherein the tube is positioned in the bore, and the device is positioned in the tube, with the said rollers opposite one of said grooves, and said rollers are then pressed radially outwardly against the wall of the tube and rotated about the axis thereof while being held against axial movement relative to the tube, so that the said tube is expanded locally into said groove by the purely radial force exerted by the rollers.

2. A process according to claim 1, wherein, after expansion of the tube into the said groove, the rotation is stopped and the rollers are moved radially inwardly before moving them axially to a position opposite another groove and repeating the process for locally expanding the tube into the said other groove.

3. A process according to claim 1 or 2 wherein the tube is provided on its internal face with cylindrical projections which are extended by suitable linking portions, the said projections being of smaller internal diameter than the tube, and being intended to be positioned before expansion, opposite corresponding grooves in the bore.

4. Process according to any of the preceding claims, wherein the width of each groove is between one third and two thirds of the length of the rollers.

5. Process according to any of the preceding claims, wherein each expansion of the tube is between 15 and 30% of the thickness of the tube.

6. A process according to any of the preceding claims, wherein the depth of the groove is such that the tube, once expansion has been carried out, cannot come into contact with the base of the groove.

7. Process for fixing a tube in fluid tight fashion in a bore substantially as herein described with reference to the accompanying drawings.

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997721 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

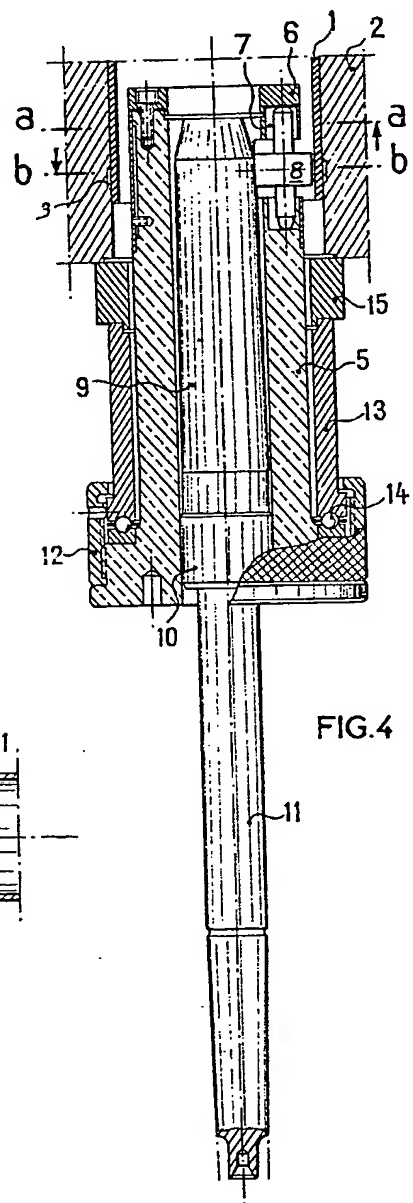


FIG.4

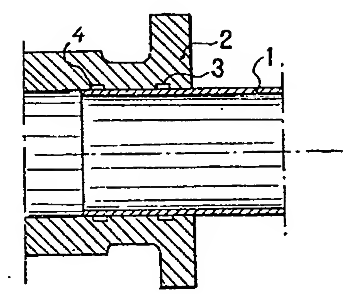


FIG. I

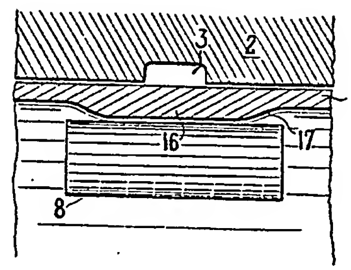


FIG.2

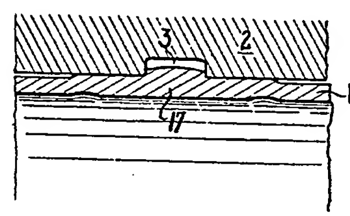
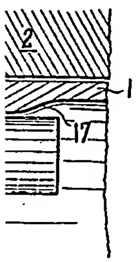


FIG. 3

997721 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3



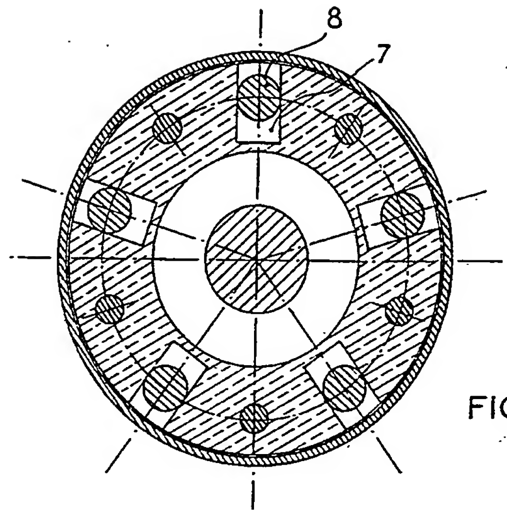
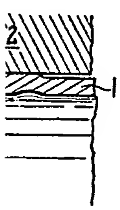


FIG.5



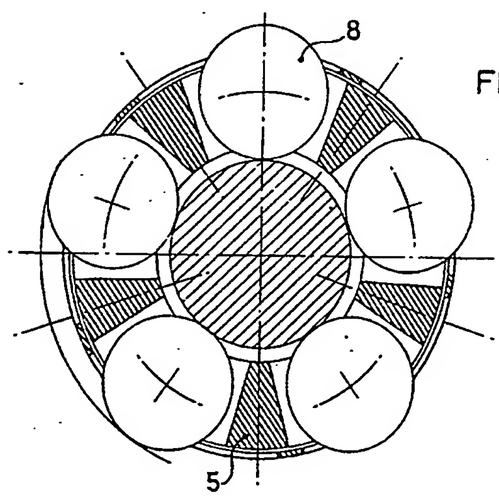


FIG.6

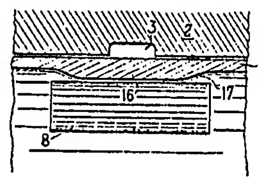


FIG.2

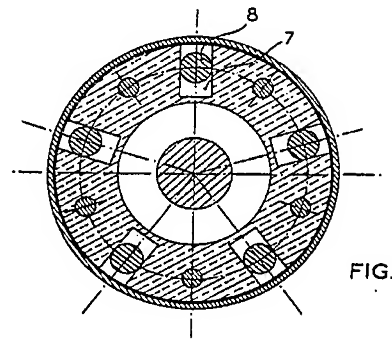


FIG.5

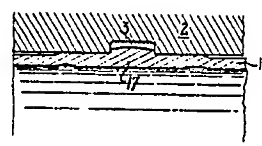


FIG. 3

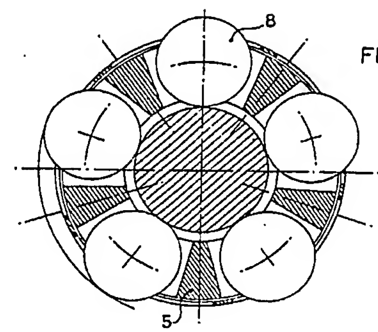


FIG.6